

What is claimed is:

1. An electron beam treatment apparatus that comprises:
  - a chamber;
  - a cathode having a surface of relatively large area that is exposed to an
  - 5 inside of the chamber;
  - an anode having holes therein that is disposed inside the chamber and spaced apart from the cathode by a working distance;
  - a wafer holder disposed inside the chamber facing the anode;
  - a source of negative voltage whose output is applied to the cathode to
  - 10 provide a cathode voltage;
  - a source of voltage whose output is applied to the anode;
  - a gas inlet adapted to admit gas into the chamber at an introduction rate;
  - and
  - a pump adapted to exhaust gas from the chamber at an exhaust rate, the
  - 15 introduction rate and the exhaust rate providing a gas pressure in the chamber;
  - wherein values of cathode voltage, gas pressure in the chamber, and the working distance are such that there is no arcing between the cathode and anode and the working distance is greater than an electron mean free path.
- 2 The apparatus of claim 1 further comprising a source of gas,
- 20 which source is a source of one or more of Ne, He, Ar, H<sub>2</sub>, O<sub>2</sub>, Kr, Xe, and N<sub>2</sub>.
3. The apparatus of claim 1 wherein a material of the surface of the cathode is selected from the group consisting of Al, Ti, Ni, Si, Mo, graphite, W, Co, and alloys of the foregoing.
4. The apparatus of claim 1 wherein a material of at least a surface
- 25 of the anode is selected from the group consisting of Al, Ti, Ni, Si, Mo, graphite, W, Co, and of the foregoing.
5. The apparatus of claim 1 wherein the source of negative voltage is capable of providing output voltages in range from about -.5 KV to about -10 KV.
7. The apparatus of claim 1 wherein the gas pressure is greater than
- 30 about 40 mTorr.

8. A method of operating an electron beam treatment apparatus that includes a chamber; a cathode having one surface of relatively large area that is exposed to an inside of the chamber; an anode having holes therein that is disposed inside the chamber and spaced apart from the cathode by a working distance; a wafer holder disposed inside the chamber facing the anode; a source of negative voltage whose output is applied to the cathode to provide a cathode voltage; a source of voltage whose output is applied to the anode; a gas inlet adapted to admit gas into the chamber at an introduction rate from a source of the gas; and a pump adapted to exhaust gas from the chamber at an exhaust rate, the introduction rate and the exhaust rate providing a gas pressure in the chamber, which method comprises:

placing a wafer on the wafer holder; and

setting the source of negative voltage, the introduction rate, the exhaust rate, and the working distance to provide values of cathode voltage, gas pressure, and working distance such that there is no arcing between the cathode and anode and the working distance is greater than an electron mean free path.

9. The method of claim 8 wherein the cathode voltage is in range from about -.5 KV to about -10 KV.

10. The method of claim 9 wherein the gas is one or more of: Ne, He, Ar, H<sub>2</sub>, O<sub>2</sub>, Kr, Xe, and N<sub>2</sub>.

11. The method of claim 8 wherein the gas pressure is greater than about 40 mTorr.